BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 03083

SUBJECT: Time Lag Associated with Remote Control of Apollo Lunar Surface TV Camera - Case 320

DATE: March 30, 1970

FROM: J. E. Johnson

ABSTRACT

The Apollo color TV camera to be used on the lunar surface for Apollo 16 and later missions is being proposed to be capable of being pointed by commands from the Mission Control Center. A time lag of about three seconds will occur between initiation of the command and observing the reaction to it when the Goldstone, California, tracking station is in use. When the Parkes, Australia station is in use, the lag will be about three and one-half seconds. It is recommended that the Earth-based camera controllers practice using simulations with delays of this magnitude.

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MEMORANDUM FOR FILE

Starting with Apollo mission 16, the color TV camera to be used on the lunar surface is expected to be capable of being controlled remotely from the MCC. This will allow the astronauts to make more efficient use of their exploration time, give flight control and scientific personnel more flexibility and freedom in examining and documenting the locale, and avoid tying up the air-ground voice circuit with televising instructions. The remote control functions will be "pan" (azimuth), "tilt" (elevation), "zoom" (focal length), and "iris" (lens opening). An astronaut will be able to override the ground commands and assume full control of the televising, if desired. The existing Apollo digital command system would be used along with a new command decoder to be located in the camera mount.

Earth-based control will introduce a significant time lag between a command initiation and an observed response. This is due chiefly to the round-trip Earth-Moon propagation time (2.5 sec.). Also contributing to the total lag are delays inherent in the command system (typically about 0.5 sec.), and if a communications satellite relay is used in conjunction with the Parkes, Australia station, an additional delay of about 0.6 sec. The total lag to be expected is about three seconds when using the Goldstone, California site, and about three and one-half seconds when using the Parkes site. See Table 1 for an itemized breakdown of these delays. Details of the ground network operation for command are given in Reference 1, and details of system delays in Reference 2. A description of the color TV camera is given in Reference 3.

Time lags of this magnitude are clearly acceptable in the context of "real-time" viewing of the lunar terrain. A potential difficulty lies in the action-reaction response of the Earth-based television controller(s) and in the rates of change chosen for the commands. Two types of commands are being considered for each control function. One will permit a continuous excursion (unless a stop were reached) at a relatively slow rate (for example, 3°/sec. has been suggested in pan and tilt). The second command type will trigger a discrete step (maybe 3° per step of camera motion). The continuous command requires as a corollary a stop command. The discrete command might require several initiations and lacks

precision in final placement. An assessment of the adequacy of these commands and of the rates and step sizes is outside the scope of this note. It should be obvious that when talking of (action) - (observed reaction) delays of this magnitude, the control will be "tricky", and will require the learning of an unnatural set of responses. Extensive practice through simulation should be accomplished beforehand to avoid loss of data during the brief time available on the moon.

Television camera commands will be in the form of Real-Time Commands (RTC's). RTC's are stored pre-mission in the core memory of the command computers at the remote MSFN sites. They are called up during a mission by Execute Command Requests (ECR's) initiated by Flight Controllers at the Mission Control Center (MCC). Upon receipt of an ECR, the requested RTC is called out of memory and a "vehicle" address (in this case, TV camera) and "system" address are added. The entire message is then "sub-bit" encoded (each information bit is transformed into a 5-bit code for error control purposes) and uplinked at a 1-kbps rate on a 70-kHz subcarrier of the Unified S-Band System. The uplink composite signal will be received by the Lunar Communications Relay Unit. (Remote control of the camera through the LM systems is also being considered.) The 70-kHz subcarrier will be sent to the TV command decoder, which will demodulate the signal, check the address and sub-bit structure and, if correct, activate the appropriate relays for television camera control. Unlike other commands, no Message Acceptance Pulses (MAP's) will be returned to the Earth from the LCRU. This will require either that the MSFN site uplinking the command be in a "MAP Override" mode or that the Flight Controller(s) at MCC concerned with the TV control ignore the REJECT signal they will otherwise receive from the MSFN site in the absence of a MAP. The TV command system is not a closed-loop system in the same sense the other Apollo spacevehicle command systems now are. The observed response of the television camera will close the loop, not the receipt of a valid command indication. Consequently, malfunction diagnosis may be more difficult.

The emphasis of this note is that there will be largely immutable time delays of a magnitude to be significant from a human factors viewpoint. In particular, the rates and step sizes selected might well benefit from a period of training simulation using the time lag values suggested here.

J. E. Johnson

2034-JEJ-drc

Attachment
Table 1

REFERENCES

1. Johnson, J. E., "Apollo Command System - Ground Network Data Flow," Bellcomm TM 68-2034-8, June 20, 1968.

2. Johnson, J. E., "Apollo Command System - Spacecraft Computer Update Delays Using the Updata Link," Bellcomm TM 69-2034-3, March 28, 1969.

3. Niemyer, L. L., Jr., "The Apollo Color Television Camera," The Westinghouse Engineer, November, 1969.

TABLE 1

COMPONENTS OF DELAY FOR REMOTE CONTROL OF TV CAMERA

	Time (ms.)
MCC processing of ECR	56
MCC-Goddard (GSFC) transfer	23
GSFC read-in at 50-kbps and processing time	25
GSFC - Goldstone transfer	35
or	
GSFC - Honeysuckle Creek,* Australia transfer via communications satellite	300
Remote Site Command Computer read-in at 4.8-kbps and processing time	152
Updata Buffer processing	30
Remote Site - Moon propagation delay (Average value, actually varies from 1200 to 1360)	1280
TV Camera Decoder read-in at 1.0-kbps	60
Moon - Remote Site propagation delay	1280
Goldstone - MCC transfer of TV picture	12
or	
Parkes* - MCC transfer of TV picture	300
Total using Goldstone	2953 or 3.0 sec.
Total using Honeysuckle Creek-Parkes	3506 or 3.5 sec.
Add a very small amount (at most 0.1 sec.) for TV picture processing en route.	

*The Honeysuckle Creek 85' diameter antenna of the Manned Space Flight Network is used for uplinking the command. The TV is received by the Parkes 210' diameter antenna. Two different antennas are also used at Goldstone, although both are called by the same location name.

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From: J. E. Johnson

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